INTERN EXPERIENCE AT

THE CONOCO VCM PLANT

An Internship Report

by

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ABSTRACT

Intern Experience at the Conoco VCM Plant. (December 1975)

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This report deals with the professional engineering experience accrued by the author during an eight-month internship with Conoco Chemicals in Lake Charles, Louisiana. Background of the internship is discussed, including the intern's position in the organization of the plant.

Major projects assigned during the internship are defined. The problem of occupational exposure to vinyl chloride, a toxic chemical, is addressed and a system for monitoring employee exposure is developed and proposed. The exposure to industrial noise at the plant is evaluated and recommendations are presented.

ACKNOWLEDGMENTS

I am indebted to Dr. R. J. Vernon, my committee chairman, for his advice, encouragement and assistance throughout my graduate program. His enthusiasm provided the catalyst without which I would not have been motivated to pursue graduate training in industrial hygiene engineering.

I am also especially indebted to Dr. R. B. Konzen for his counsel and guidance through difficult periods.

I must also extend my appreciation to my graduate committee members, Dr. M. J. Fox, Dr. E. M. Bailey and Dr. C. A. Phillips for their valuable contributions to my education and development.

DEDICATION

to Linda

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INTRODUCTION

Doctor of Engineering Internship

This report deals with the professional engineering experience accrued by the author during an eight-month Doctor of Engineering Internship served with Conoco Chemicals, Continental Oil Company, Westlake, Louisiana, from January 6, 1975 through August 22, 1975.

The internship is an integral part of the degree requirements for the Doctor of Engineering degree. The objectives are two-fold: (1) to afford to the engineering student the opportunity to apply his knowledge and education to the solution of a specific practical problem of interest to an industrial firm and (2) to permit the student to perform in a non-academic environment and to gain an awareness of the organizational approach to problems [1].

Negotiations for an internship position with Continental Oil Company were initiated as a result of the financial support by Conoco to Texas A&M University through an Industrial Hygiene Engineering Fellowship. Correspondence with Dr. Robert Lembke, Corporate Medical Director, soon provided a position at the Conoco Chemicals Complex in Lake Charles. Primary assignment was to the VCM Plant which produces vinyl chloride monomer.

Conoco VCM Plant

The Conoco VCM Plant at Westlake, Louisiana, was constructed with the latest technology in 1968. It was, at that time, one of the largest volume plants of its kind in the world. Annual production is 300,000 metric tons. A major portion of the vinyl chloride monomer (VCM) produced in Lake Charles is shipped to Conoco polyvinyl chloride (PVC) facilities in Oklahoma and Mississippi. Conoco also ships this important basic material to fifteen countries and is currently the largest U.S. exporter of VCM.

Vinyl chloride is a clear colorless gas which, upon polymerization, forms polyvinyl chloride resin, a basic raw material for about 55 percent of the plastic products currently in use.

VCM has recently been labeled as a carcinogen by the federal government. Consequently, stringent controls have been placed upon its use and manufacture. Allowable exposures to employees have been reduced 99.8 percent, from 500 parts per million to one part per million as an eight-hour daily average. Tremendous sums of engineering time and capital have been invested in the plant to reduce workers exposure to VCM gas to meet the new compliance limit.

At the VCM Plant the compliance effort is jointly maintained among the process engineering department, the safety department, and the laboratory. Figure 1 shows the organization of the plant. Direct supervision for the internship

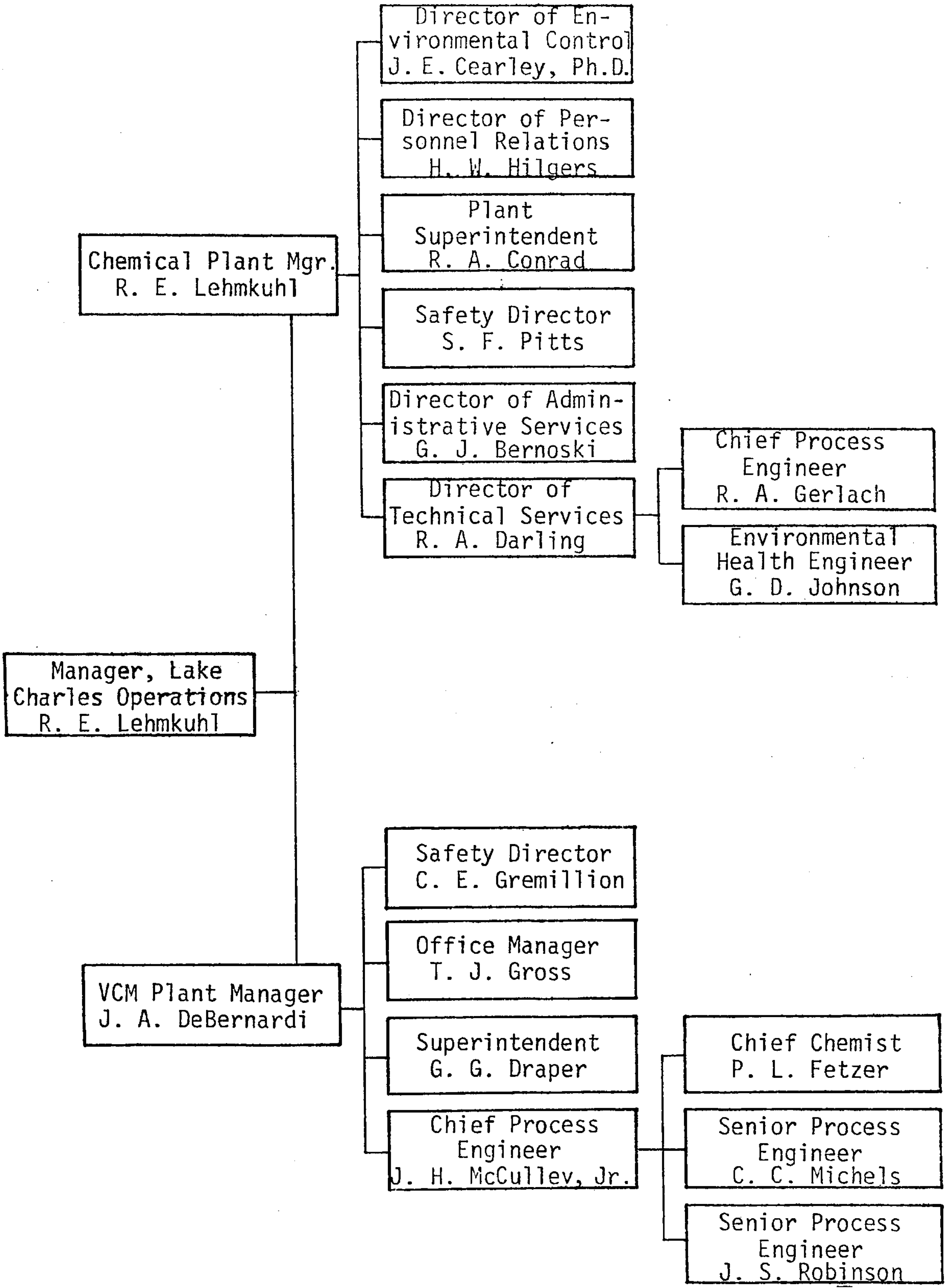


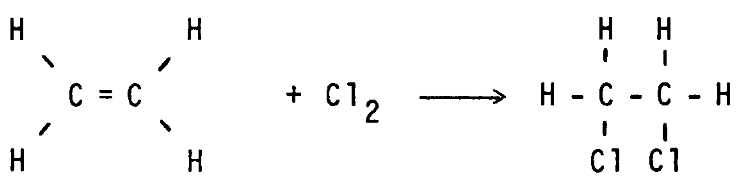
Figure 1. Organizational chart.

was assigned to Mr. C. Earl Gremillion, C.S.P., the plant Safety Director. To supplement Mr. Gremillion's supervision of the internship, an advisory committee was formed consisting of Mr. G. D. Johnson, P.E., Environmental Engineer for the Chemical Complex, and Dr. J. E. Cearley, Director of Environmental Control. This committee held regular meetings to advise and guide the intern.

Process Orientation

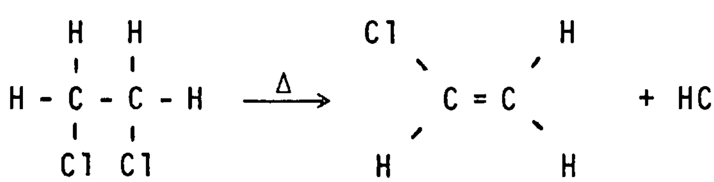
Vinyl chloride monomer is synthesized from feedstocks of ethylene and elemental chlorine via direct chlorination and oxychlorination and subsequent thermal "cracking."

The process is initiated by the direct chlorination of ethylene with chlorine to form ethylene dichloride (EDC), a chemical intermediate.



(1)

EDC, in crude form, undergoes purification by fractionation. Pure EDC is then thermally "cracked" in process furnaces to form VCM, hydrogen chloride (HCl) and uncracked EDC.



(2)

The hydrogen chloride by-product is recycled to the oxychlorination stage. Here it is reacted with oxygen from compressed air and more ethylene to form more crude EDC.

$$2\ \begin{matrix} H & & & & H \\ & \diagdown & & \diagup & \\ & & C = C & & \\ & \diagup & & \diagdown & \\ H & & & & H \end{matrix} + 4HCl + O_2 \longrightarrow 2H - \underset{\underset{Cl}{|}}{\overset{\overset{H}{|}}{C}} - \underset{\underset{Cl}{|}}{\overset{\overset{H}{|}}{C}} - H + 2H_2O \qquad (3)$$

Figure 2 is a simplified schematic of the process flow.

Vinyl Chloride Overview

"Vinyl chloride appears to be a material of relatively low toxicity. The principal [physiological] response seems to be one of central nervous system depression, which may result in symptoms of dizziness and disorientation . . ."[2] This statement is exemplary of the consensus on the toxicity of vinyl chloride prior to January 1974. It was considered hazardous primarily as a flammable gas and therefore capable, at high concentrations, of fire and/or explosions.* Recently, a definite relationship between chronic VCM exposures and angiosarcoma, a rare and fatal liver cancer, has been demonstrated. Worldwide, slightly over 30 deaths to angiosarcoma have been attributed to occupational exposure to VCM.

As a result, the U.S. Department of Labor, Occupational

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*The flammable range for VCM is 3.6 percent to 26.4 percent which corresponds to 36,000 ppm and 264,000 ppm, respectively.

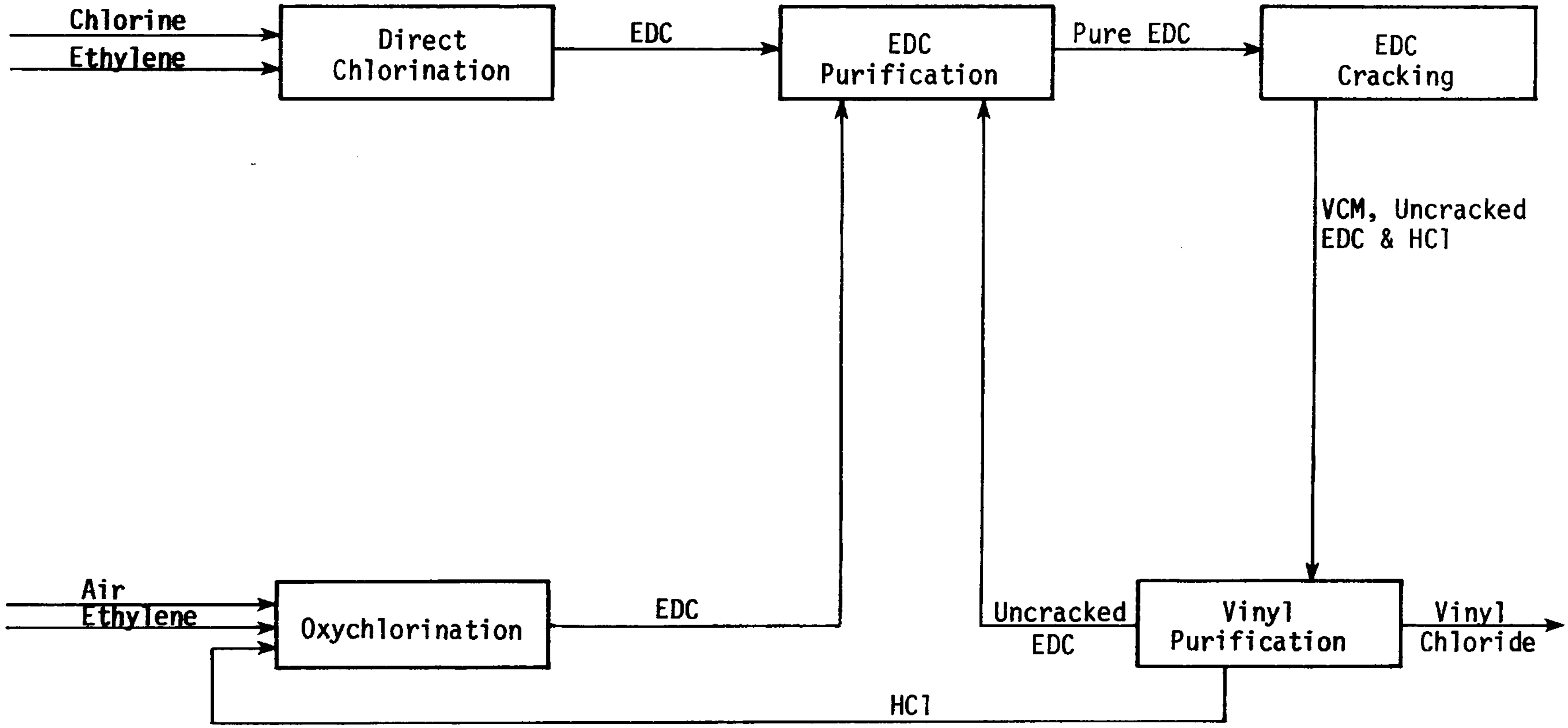


Figure 2. VCM Plant flow diagram.

Safety and Health Administration (OSHA) has ordered a sharp reduction in workers' exposure to vinyl chloride. The new standard, effective April 1, 1975, requires that VCM levels in the air that workers breathe be held to one part vinyl chloride per million parts of air by volume, averaged over an eight-hour shift. Actual levels may exceed one part per million (ppm) for short periods, but they must average out to no more than five ppm for any fifteen minute period within the eight-hour time span [3].

The standard requires that the one ppm level be attained by "engineering and work practice controls" whenever such controls are "feasible." Respiratory protection can be used as a control measure only when all other measures fail to reduce VCM concentrations to within the permissible limits.

Explicit requirements are also outlined for personnel monitoring, medical surveillance, record keeping, respiratory protection and regulated areas. To meet the personnel monitoring requirements, the employer must measure the exposure of each employee. Such monitoring must be repeated at least monthly for any employee exposed in excess of one ppm. It must be repeated quarterly for any employee exposed in excess of one half of one ppm. While no particular monitoring technique is specified, minimum accuracy requirements are outlined in the standard. The company (employer) must be prepared to demonstrate that its personnel monitoring system meets these accuracy criteria.

In the area of medical surveillance, a program must be instituted for each employee exposed to VCM exposed in excess of the "action level" (0.5 ppm). The program must include, at a minimum: (1) a general physical examination with specific attention to dysfunction or abnormalities of the liver, kidneys or spleen, (2) a medical history, and (3) a blood profile. These requirements must be repeated semiannually for employees in VCM service for ten years or more and annually for all other employees. The standard requires that these and all other records associated with VCM exposure be maintained for a period of not less than thirty years.

Any area of the plant in which ambient VCM concentrations are consistently in excess of the permissible limit (1 ppm) must be designated by appropriate signs as regulated areas. Access to these areas must be limited to authorized personnel. A daily log must be maintained of the name and social security number of all persons entering a regulated area.

VCM MONITORING SYSTEM

The primary assignment for the internship was to investigate alternative approaches to personnel monitoring of VCM exposure and determine their feasibility, both technical and economic. The first step was to become familiar with the existing personnel monitoring technique and learn its advantages and disadvantages.

Current Monitoring Technique

The existing system of personnel monitoring for organic vapor (including VCM) involves the use of dosimeters. The dosimeter is a small portable device which, when carried on the person of an employee, integrates his average exposure to VCM throughout the work-day. The device consists, briefly, of a small battery-powered air pump which draws a measured volume of air from the breathing zone of an employee, through a tube filled with activated charcoal. Any organic vapor present will be adsorbed on the charcoal. The amount of VCM adsorbed is measured (by gas chromatography) so that the average atmospheric concentration at the breathing zone can be calculated [5].

This technique represents accepted practice in industrial hygiene and is entirely adequate in classical monitoring applications. For example, the evaluation of an occupational exposure to a toxic substance generally consists of the following sequence.

An adequate number of samples are taken and analyzed, ideally representing a "typical" work experience. The sampling results give an indication as to whether a potentially hazardous exposure exists. If the exposure is excessive, steps are taken to establish appropriate controls. Repeated monitoring establishes the effectiveness of the controls. When exposures have been reduced to "safe" levels, continued personnel monitoring is generally unnecessary.

For this type of monitoring, the use of dosimeters is ideal. The sample is drawn directly from the breathing zone of the worker eliminating many of the sources of error in estimating his exposure.

However, the system does have its disadvantages. It is cumbersome for the employee who must wear the dosimeter. It requires a significant amount of laboratory analysis time and it necessitates scheduling and training of employees in the proper care of the dosimeters. Compliance with the new OSHA standards requires the acquisition of tremendous amounts of data. Personnel monitoring becomes a continuing program rather than a matter of taking and analyzing infrequent samples. Compliance with OSHA standards using dosimeter monitoring methodology can impose a very significant workload in laboratory analysis time and record keeping man-hours.

Automated Concept

A system for monitoring personnel exposures to VCM in compliance with the OSHA standards should meet the following criteria:

1. Effectively measure personnel exposures to VCM, meeting the requirements of the OSHA Standard for Exposure to Vinyl Chloride (29CFR 1910.93q).
2. Impose a minimum workload on laboratory and administrative personnel.
3. Possess alarm capabilities which could alert employees in the event that VCM concentrations exceed a preset value.
4. Be capable of assisting in the control of access to regulated areas and compiling records of authorized personnel who have entered the areas.
5. Be technological and economically feasible.

The search for an improved technique for meeting these criteria for VCM monitoring had, as its ultimate goal, the elimination or at least reduction of the manual processing time. Such a search naturally gravitates toward methods of automating the monitoring "system." A monitoring system to measure time-weighted average (TWA) exposure to VCM must have the capability to measure and correlate three basic input variables: (1) ambient VCM concentrations in various plant areas, (2) employee locations, and (3) duration of exposure.

Measurement of System Parameters

The first parameter, ambient VCM concentrations, is currently being monitored by two process gas chromatographs located in the plant control room. Each of these chromatographs sequentially monitors ten fixed-point locations in the plant. Therefore, ambient VCM concentrations at twenty fixed-point locations are monitored throughout the day. Each point is measured at approximately ten-minute intervals. Output from the chromatographs is recorded on strip charts in the control room and maintained on file.

The two remaining parameters, employee location and time of exposure can be measured by any one of several techniques.

Motion and Time Study. One classical method for predicting employee locations involves the use of motion and time study analysis. This technique could produce a chart for each job classification outlining location versus time for a typical work shift. A continuing work sampling plan could be employed to ensure that the actual work scheme for each job classification did not vary significantly from the initial sequence. This method could have application in plants were job tasks are repetitive and therefore predictable with a significant level of accuracy. However, in continuous chemical process operation, the job tasks of operations and particularly of maintenance personnel are so variable that a motion/time study analysis could not reliably predict location versus time charts for all employees.

<u>Transmitter</u>. An innovative approach to monitoring employee location employs the use of miniature electronic transmitters, carried by each employee so that his exact position could be continuously monitored and recorded. While such a technique would obviously yield the ultimate in accuracy, it would be cost-prohibitive for most applications. In addition, employee reaction to a device whereby management could continuously monitor their whereabouts would undoubtedly be strongly negative.

<u>Badge Readers</u>. A third approach to monitoring employee locations utilizes a network of badge readers located at strategic points in the plant. This not only appeared to be the most cost-effective technique, but also overcomes the basic objections to time and motion and transmitter techniques. By locating badge readers at the entrances to critical areas of the plant (e.g., regulated areas) the time during which any employee might remain in an area with potentially high ambient VCM levels could be logged. Each employee would carry a unique identification card (existing ID cards could be used when appropriately punched) and would be required to "punch in" and "punch out" upon entering and exiting regulated areas.

<u>Data Compilation and Reduction</u>. Data from two of the sources outlined above (i.e., gas chromatographs and badge

readers) are required to calculate exposures (TWA) of personnel. First, the ambient VCM concentrations as a function of time in various plant areas are measured by the gas chromatographs and recorded. Second, personnel location data are generated by the badge reader network. The data from both sources must be compiled, correlated and reduced to generate daily TWA exposures for plant employees. The TWA exposure for an individual is calculated using the following equation:

$$TWA = \frac{\sum_{i=1}^{n} (T_i)(C_i)}{\sum_{i=1}^{n} (T_i)} \qquad (4)$$

where C_i = concentration in ppm

T_i = time exposed at that concentration in hours

Such voluminous calculations are best automated to be practically useful. It would seem, therefore, that the most appropriate system for the Conoco VCM Plant would be one which utilized the existing chromatographs, coupled with a network of strategically placed badge readers and centered around a minicomputer to compile and reduce the data to useful form (see Figure 3).

Proposed System

Several firms currently market systems utilizing badge reader networks similar to that outlined in Figure 3.

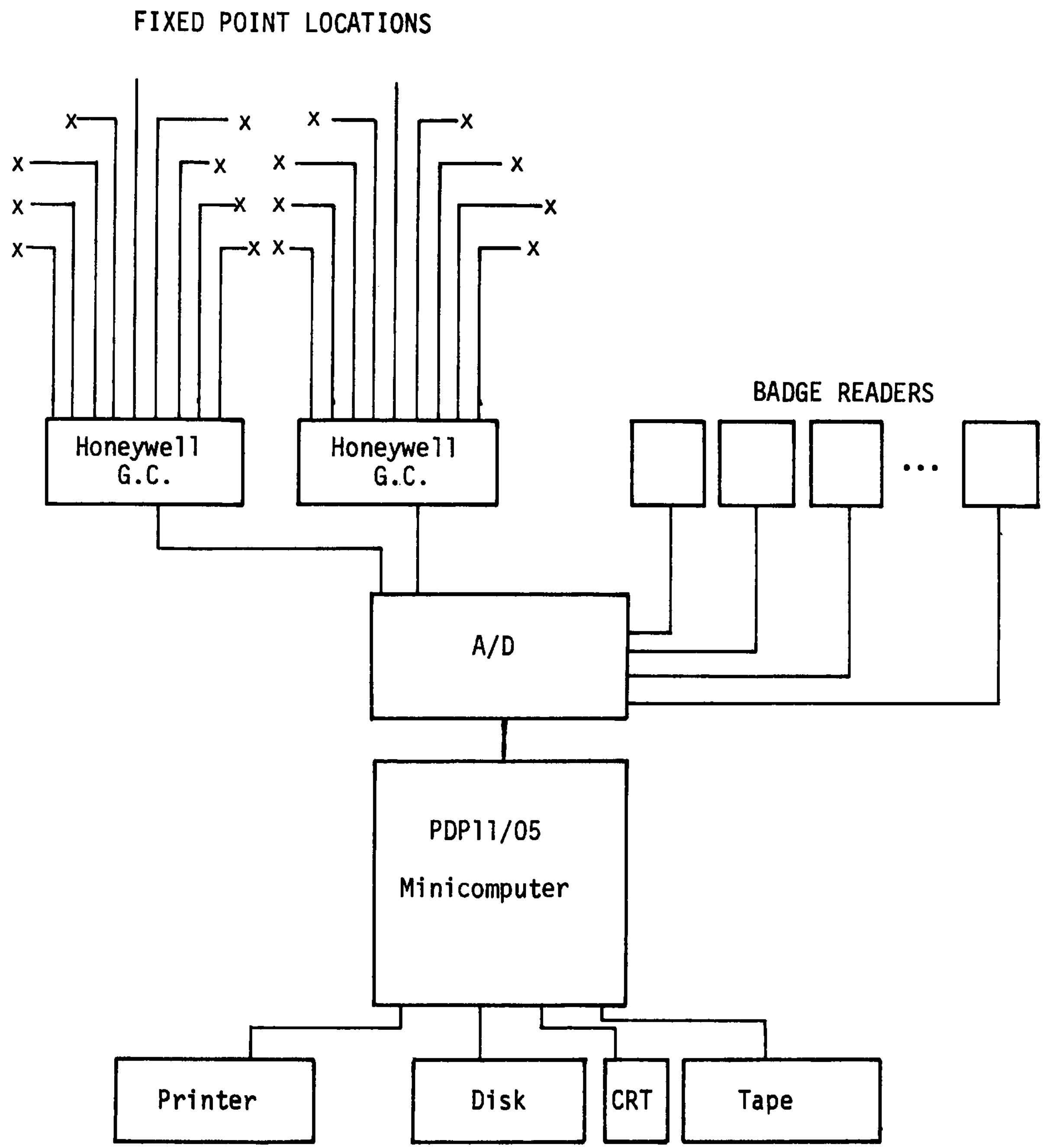


Figure 3. Automated monitoring system.

Preliminary quotes indicate that TANO Corporation of New Orleans offers the most cost-effective approach. TANO's VCM monitoring package employs a Digital PDP-11 minicomputer to continuously monitor the two input variables. Any measured concentration higher than a preset limit would cause an alarm system to activate. Each person entering the plant would be issued a unique badge number and a wallet-sized card. Upon entering one of the designated areas, employees would insert their card into the badge reader. A background ambient concentration level is used for individuals not registered into one of the designated areas. At the end of each shift, VCM concentrations compiled from chromatograph input, coupled with badge reader inputs, are integrated into TWA exposures for each employee. These data are used to produce reports such as:

1. A daily report of VCM exposure for each person in the plant during the preceding twenty-four hours.
2. A letter individually addressed to each person exposed to VCM levels higher than the permissible limit (an OSHA requirement).

System components and preliminary price quotes are listed below:

PDP-11 Computer w/32K Processor

7 Badge Readers

TDAC Interface

RSX11-M System Software

Application Software

Installation

Dual Cassette

Disk

1A36 Printer

Bootstrap Cassette

System Price $58,000

Additional Badge Readers ($1650 ea.)

VCM maintenance personnel would provide materials (wire, conduit, etc.) and labor for installation of badge readers and equipment. Expertise for system "hook up" is included in quoted price.

Accuracy Verification

Accuracy Requirements

The automated monitoring system, as proposed by TANO Corporation appears to meet the requirements initially established for an automated monitoring system with one possible exception--accuracy. The accuracy of personnel monitoring via fixed point monitors has not been verified.

Paragraph 1910.93 q (c) (4) of the OSHA VCM standard states:

> The method of monitoring and measurement shall have an accuracy (with a confidence level of 95 percent) of not less than plus or minus 50 percent from 0.25 through 0.5 ppm, plus or minus 35 percent from over

0.5 ppm through 1.0 ppm, and plus or minus 25 percent over 1.0 ppm.

If an automated monitoring system is to be used to demonstrate compliance with the OSHA regulations, then some technique is needed to verify the accuracy of the system.

One way to gage the results obtained from an automated monitoring system is to compare the system output to the results obtained by the recognized monitoring technique (personnel dosimeters). If the data derived from monitoring an individual via an automated system are indeed valid, they should compare very closely with the results from monitoring that same individual with a personnel dosimeter.

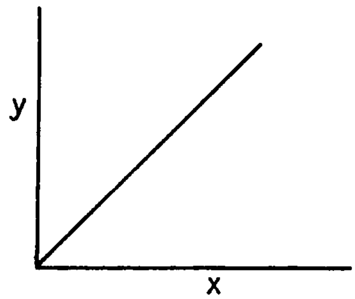
Regression Analysis

Regression is a mathematical technique used to measure and quantify the relationship between two or more variables. In this application there are two variables; y, the value obtained from monitoring an individual with a dosimeter and x, the value obtained by monitoring that same individual via the automated system. Ideally, the two values would be exactly the same if a large number of samples were taken, the relationship between x and y would be expressed as

$$x = y \qquad (5)$$

in which case the regression line would be a straight line, starting from the origin and extending at an angle of

45 degrees.



In actuality, due to the accumulation of error from many sources, the relationship will be something other than a simple x = y. However, if a consistent relationship exists, its parameters can be determined through a regression analysis and a "calibration curve" for the automated system can be derived.

Experimental Procedure

Data Collection. During the month of June 1975, each employee who was scheduled to be monitored via personnel dosimeter was also issued a time chart (see Figure 4) and requested to maintain a record of his location and time expended at that location during that shift with particular interest to the plant regulated areas. The objective of this time chart was to obtain the same data that would be collected by the badge reader network, if it were installed and operational. That is, the time charts would provide information as to when and how long the employee was in the critical areas of the plant.

	Maint.Shop/Office	Control Room	Block I (except reg. area)	Reg.Area--Block I	Block II	EDC Tank Tops	Loading Racks	Vent Recovery Unit	VCM Loading Pumps	VCM Transfer Pumps	Lab Regulated Area
7:00	✓										
7:15		✓									
7:30			✓								
7:45	✓										
8:00			✓								
8:15			✓								
8:30	✓										
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3:30	✓										

Figure 4. Time chart.

This worker location information was then used in conjunction with the strip chart output from the fixed point gas chromatographs to calculate a TWA exposure for each employee (using equation (4)). The data thus calculated represented a simulation of the data that would be obtained from an automated monitoring system and represents the x variable in the regression. The results from the dosimeter evaluation on each individual represent the y variable in the regression analysis.

Mathematical Analysis. Any linear relationship between two variables can be expressed in the form:

$$y = a + bx$$

In a linear regression, the unknowns in the equation (a and b) can be computed using the method of least squares. The formulae are shown below:

$$b = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n} (x_i - \bar{x})^2} \qquad (6)$$

$$a = \bar{y} - b\bar{x}$$

Since the relationship is not strict, i.e., there is some variance of the data from the regression line, the confidence limits for y for an observed value of x can be calculated using the following formulae:

Confidence limits for y:

$$y = a + bx \pm t_{\alpha/2;n-2}\, S_{y/x} \sqrt{\frac{1}{n} + \frac{(x - \bar{x})^2}{\sum_{i=1}^{n} (x_i - \bar{x})^2}}$$

where $t_{\alpha/2;n-2}$ = the t statistic for n - 2 d.f. and $\alpha/2$

$$S_{x/y} = \frac{\sum(y_i - \bar{y})^2 - b \sum(x_i - \bar{x})(\bar{y}_i - \bar{y})}{n - 2}$$

In this application a was calculated to be 0.0984 (see Appendix A) and b was calculated to be 0.3565. Therefore, the regression line or functional relationship between x and y can be expressed as:

$$y = a + bx = 0.0984 + (0.3565)x$$

The variance of the data from the regression line was quantified by calculating the upper and lower 95 percent confidence limits of y for particular values of x. These confidence limits are shown as PP' in Figure 5. Sample calculations and data are shown in Appendix A. The graph shown in Figure 5 is essentially a calibration curve for the simulated automated monitoring system. It is used to determine the actual exposure of an employee who has been monitored via the automated system.

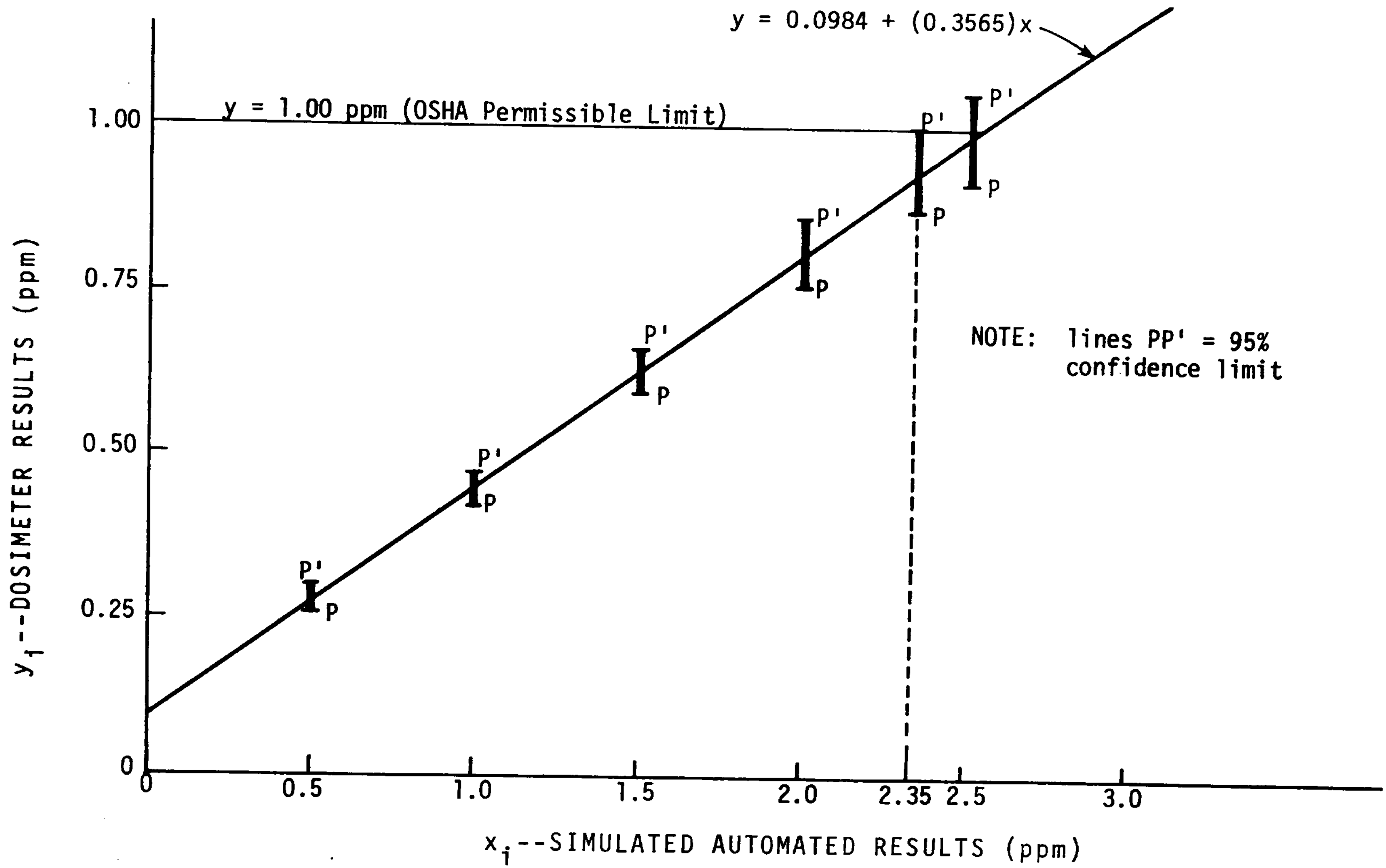


Figure 5. Regression line.

To use the graph, find the x value obtained from monitoring an individual using the automated system. The "actual" exposure of that individual is the corresponding value along the y-axis. For example, if automated monitoring results indicated that an individual was exposed to 1.5 ppm, Figure 5 would be used to show that his actual exposure was approximately 0.63 ppm. Moreover, the graph indicates that we are 95 percent confident that his actual exposure is between 0.60 ppm and 0.67 ppm.

For purposes of OSHA compliance we can be 95 percent confident that an employee has not been overexposed if, in this example, his automated monitoring results are 2.35 ppm or less.

The results of the regression analysis show that there is a predictable relationship between the results obtained with dosimeter monitoring and those obtained through a simulated automated technique. An automated system, properly designed and installed, could be used to demonstrate, with 95 percent confidence, that employees are not exposed to VCM in excess of the permissible limit.

In this limited study, the resulting absolute accuracy of the system did not meet the stringent OSHA requirements outlined previously. However, several actions are available which could reduce the confidence interval. For example, the method of tracing employee position in this experiment (by means of the time chart) was admittedly crude. With a badge reader network actually installed, the data obtained would be much more precise. Consequently, a more precise calculation of an individual TWA exposure would be possible. In addition, after installation of the system, the computing power afforded by the PDP-11 minicomputer would enable the operator to select the most appropriate input data to match dosimeter results.

In summary, it is felt that an automated system for VCM monitor, when properly designed and installed can be used to effectively evaluate personnel exposure to VCM vapors. There is no reason why the automated concept could not be successfully applied to other environmental monitoring problems.

Lastly, it was shown (proprietary information) that the automated system can be economically justified by its savings in laboratory and administration man-hours.

EVALUATION OF NOISE EXPOSURE

Background

The objective of this project was to assess the Conoco Noise Reduction Program as implemented in the VCM Plant and to make recommendations to ensure compliance with the forthcoming OSHA standard on occupational noise exposure.

OSHA officials have predicted promulgation of a permanent standard sometime between mid-October 1975 and January 1976. The proposed standard requires that:

1. Employee exposure to continuous noise must be limited to 90 decibels A-weighted (dBA), time-weighted average over an eight-hour work day. A new provision is that an eight-hour exposure to 85 dBA would constitute a daily noise dose of 50 percent of the allowable limit.
2. Workplace noise levels must be monitored annually to determine if any employee is exposed to 85 dBA or higher, and monitoring must take place within 30 days of any changes in workplace equipment or process which might affect plant noise levels.
3. Engineering controls must be developed and implemented where feasible. Personal protective equipment may be used as a control only when engineering control measures have failed to

reduce noise exposure to acceptable levels.

4. A program for annual audiometric testing for all employees exposed to 50 percent of the allowable limit or more.

The noise abatement program, established several years ago at the VCM Plant had the avowed goal of 92 dBA or less in all plant areas. This level would permit maintenance men to work in any area of the plant for as much as six hours per workday without receiving an excessive dose. With a few isolated exceptions, this goal has been reached. It, therefore, appears that compliance with the new OSHA noise standard will not pose any unsurmountable problems for this plant.

Grid survey data indicate that the continuous background sound levels in the operating area range from 85 dBA to 87 dBA. A few areas still exceed the 92 dBA goal set by Conoco (and the OSHA eight-hour limit of 90 dBA). These areas are not routine work stations for any employee and, therefore, do not necessarily create daily noise doses exceeding the compliance limit. However, some maintenance tasks require that workers remain in high noise areas for sufficient time periods to receive an excessive dose.

Data obtained with audiodosimeters confirmed that there was not a noise exposure problem in the plant for routine operations. Five-day averages of noise doses for selected job classifications in maintenance and operations showed a typical daily dose of less than 40 percent of the allowable limit. However, there are some job tasks in the plant which do result in overexposure. Recommendations for the solution of these specific problems are contained within this report.

Survey and Results

Sound levels in the office areas, warehouse, laboratory and most outside work areas are consistently below 90 dBA, the OSHA eight-hour maximum for continuous exposure. Overexposure within an eight-hour workday will not occur in these areas.

Grid Survey. Most of the significant noise sources in the plant were located within the battery limits, block I and block II. The first step in this study was to measure the sound levels at twenty-foot grid intervals throughout the operating area. Measurements were made with a General Radio Model 1565-B sound level meter which meets OSHA requirements. Five readings were taken at each grid location on non-successive days at random times to arrive at the typical noise level for each point.

The following equation is used to calculate average sound levels:

$$L = 10 \log[\text{antilog} \frac{L_1}{10} + \text{antilog} \frac{L_2}{10} + \ldots + \text{antilog} \frac{L_n}{10}] - 10 \log n$$

where L_i = random sound level readings

L = average sound level

Two grid surveys were made, one at full production rates and one at rates of approximately 40 percent. The higher noise levels during full rates reflect higher flow rates through valves, pumps, etc. Figure 6 shows the results of the first grid survey. Figure 7 shows the results of the grid survey taken at the higher production rates.

Sound levels measurements were also made around the more intense noise sources in the plant where the grid survey data reveal sound levels which could cause personnel exposure problems. The seven major high noise areas and their primary noise sources are listed below.

	SOUND LEVEL (dBA)
1. BL 301 Oxy-Air Compressor Area	
DeMag Compressor, inside enclosure	96
Adjacent to enclosure	92
Quench Col. Reflux and HCl Feed Pumps (P202A&B)	91
2. BL 502 Refrigeration Compressor Area	
Inside enclosure	94
Steam valve to HCl reboiler (FRC 204)	95
3. Chlorine Compressor Building	92-95

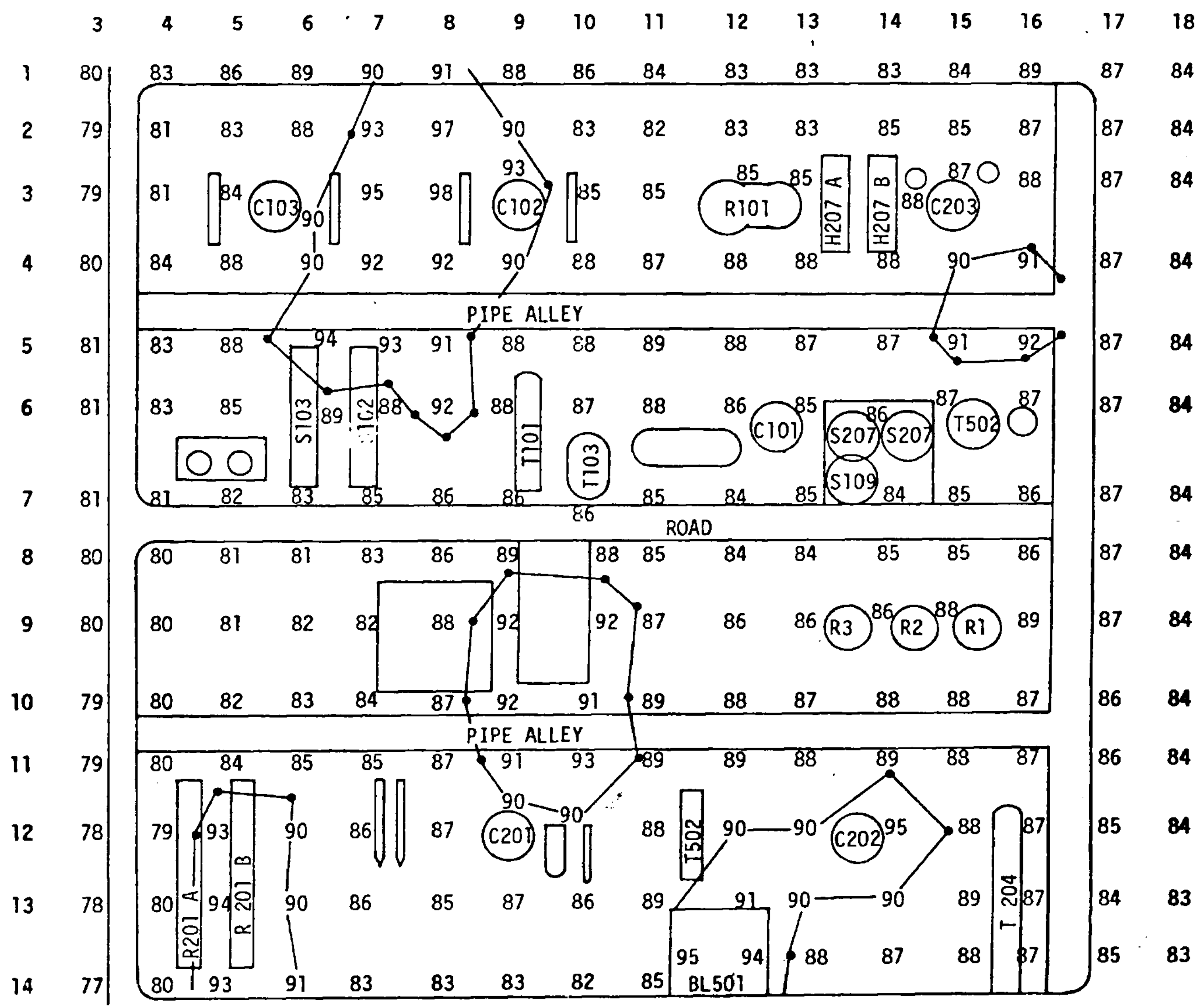


Figure 6. Average sound levels--low production rates.

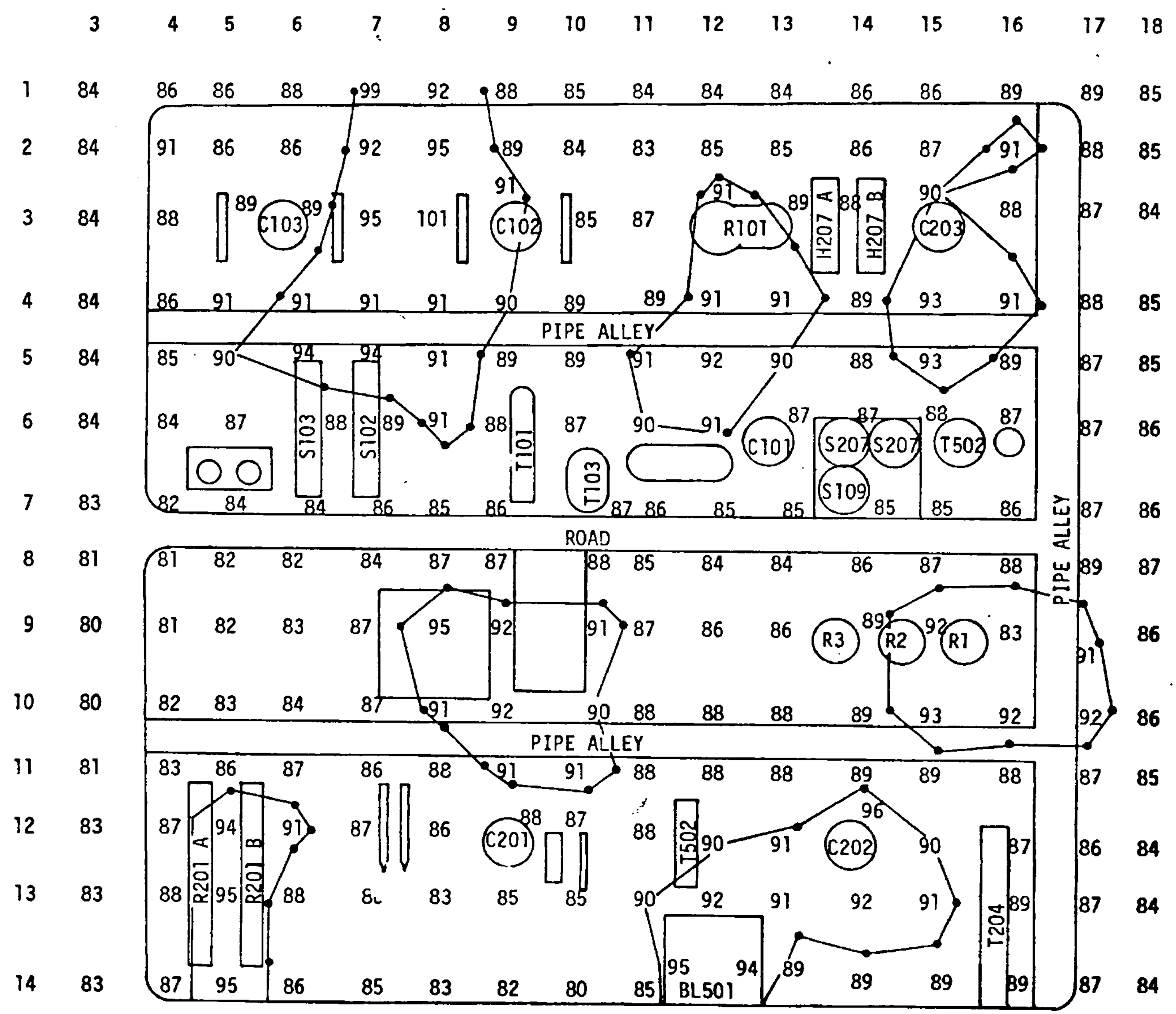


Figure 7. Average sound levels--full production.

	SOUND LEVEL (dBA)
4. West End of Block I	
Steam valves to light ends reboiler (FRC109 & 124)	101
Heavy ends reflux pumps (P106 A&B)	95
Light ends reflux pumps	94
5. East End of Block I	
Boiler feed water pumps (P502 A&B)	92
Steam valve to vinyl reboilers (HCV272)	91
Breakdown, 150 to 50% steam (PIC506A)	91
6. Furnaces (R201,A&B)	
Between	94
Adjacent	92
7. East End of Block II	
Ethylene feed valve to oxy (FRC 313)	88-98

The general noise level in the process area is such that excessive exposure could occur to personnel required to work in the high noise areas listed above for extended time periods. Because accurate data as to the amount of time employees remain in high noise areas were not available, the extent of the noise exposure problem in the plant can be most accurately determined only through the use of audiodosimeters.

Audiodosimeter Survey. The audiodosimeter is a portable instrument which, when carried on the belt of an employee for an eight-hour shift, integrates his time-weighted average exposure and computes his daily noise dose as a percentage of the allowable limit. Five-day averages were determined for selected operations and maintenance personnel.

Operations. During normal plant operations outside operators for block I and block II make periodic sampling rounds through the process area. They typically spend one to four hours per shift in the unit. Audiodosimeter analysis of both jobs for all three shifts (day, evening, and night) indicates that the average noise dose is approximately 28 percent of the allowable limit for the block I operator and 27 percent for the block II operator (see Figure 8). Thus, it appears that operations personnel are not over-exposed to noise during normal plant operations. However, maintenance problems, process upsets or other abnormalities could occasionally require more time in high noise areas with a resulting potential for an excessive noise dose.

Maintenance. Whereas the routine of the outside operators is comparatively repeatable and predictable, estimation of a "typical" daily noise dose for maintenance employees presents a substantial problem. On any specific day, maintenance work might require that an employee remain in high noise levels for extended time periods. That same employee might receive little or no exposure to high noise

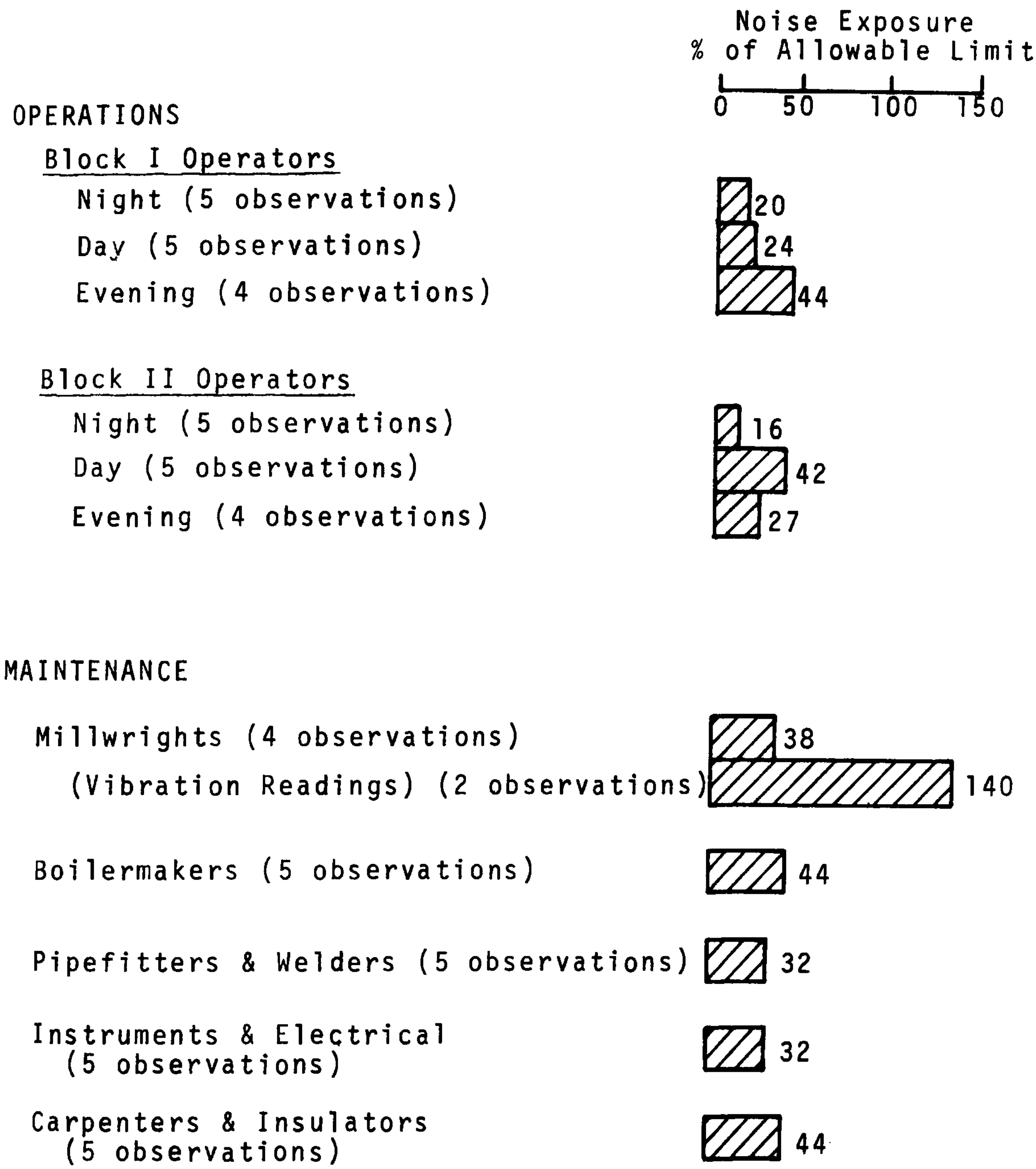


Figure 8. Noise dosimeter data summary.

levels on the following day. The audiodosimeter data for maintenance personnel reflect this variability. There appears to be no significant difference between crafts, i.e., no one craft was significantly more exposed than the others. Overall, the daily noise dose for maintenance was 37 percent. Although somewhat higher than operations, this dosage does not represent a compliance violation.

One job task, compressor vibration reading, did result in an excessive exposure (140 percent).

Conclusions

The existing noise environment and employee work practices do not result in overexposure to noise on a routine basis as defined by the proposed OSHA standard. However, there are jobs which periodically require employees to remain in high noise areas for sufficient periods to constitute an excess in exposure. These exposures, while non-typical, are nonetheless hazardous and should be controlled. Various avenues are available to ensure compliance.

Recommendations to Achieve Compliance

General. There are three recognized techniques of controlling noise exposure. In their normal order of preference, these are:

1. Engineering controls--redesign, replacement, or enclosure of high noise sources.

2. Administrative controls--rearrange work schedules so that employees are not required to remain in high noise areas for sufficient time to receive an excessive dose.
3. Personal protection equipment--issue and enforce the use of hearing protection (plugs or muffs) in high noise areas.

The proposed standard requires that all "feasible" engineering and administrative controls be implemented to bring noise exposures to within permissible limits. Personal protective devices are deemed appropriate for use only if engineering and administration controls fail to adequately reduce noise exposure.

Engineering Controls

West End of Block I. "Whisper Trim" valves for the reboilers on the light ends column have been ordered and received. Installation of these acoustically designed valves should significantly reduce the noise levels in this area.

Demag Compressor (BL301). Placing sound absorbent material on the walls of this compressor building should reduce noise levels inside from 94-96 dBA to 90-92 dBA by reducing reverberation of sound. Additional reduction could be obtained by lagging the discharge line with a high temperature vibration damping compound. These control measures should reduce the noise level to the 92 dBA goal originally established for the plant. [Note: These are the Conoco-established goals.]

Propylene Compressor (BL502). Sound absorbent material on the building walls should reduce the sound levels to within the 92 dBA goal in this area also.

Others. Other equipment in the plant occasionally generates excessive noise levels. For example, the sound power level of a pump or valve is dependent upon the flow rate through it. Therefore, the noise level in the vicinity of that piece of equipment would vary with plant production rates. It is not feasible to replace or redesign each piece of equipment which occasionally generates high noise levels. However, equipment with high noise characteristics can be eliminated by attrition. Sound power level should be among the primary design criteria for any new or replacement equipment considered for purchase by the plant. The maximum acceptable sound power level should be included in the design specifications.

Administrative Controls

The three primary high noise levels in the plant (BL501, BL301, and chlorine compressor building) have been designated as high noise level areas. Access to these areas is controlled and limited to authorized personnel.

Personal Protection Equipment

The data indicate that excessive noise doses in this plant are limited to non-typical and/or infrequent job tasks which require abnormal exposure times in the high noise areas. Paragraph 1910.95 (c) (3) of the OSHA Standard states:

> Hearing protectors may be provided to, and used by an employee to limit noise exposures in lieu of feasible engineering and administrative controls if the employee's exposure occurs no more than one day per week.

Therefore, it appears that compliance can be attained by enforcing the use of personal hearing protection for jobs in which high noise levels are encountered. Specifically, hearing protection should be mandatory for entry into the following areas:

1. Chlorine compressor building
2. BL501 building
3. BL301 building
4. BL302 building (when running)
5. Between R201 A&B

In addition, hearing protection should be required and its use enforced for the following jobs:

1. Taking compressor vibration readings
2. Using needle scalers
3. Using the band saw
4. Using the grinder

5. Sandblasting
6. Any time when the job necessitates remaining in high noise levels for extended periods of time

Hearing Conservation Program

Paragraph 1910.95 (g) of the proposed noise standard specifies that all persons who receive a daily noise dose equal to or exceeding 0.5 (50 percent of the allowable limit) must be covered by a hearing conservation program. At a minimum, such a program would include the following:

1. A baseline audiogram for each employee who receives a daily dose in excess of 0.5.
2. Subsequent annual audiometric testing.
3. Ear protectors for all employees who show a significant threshold shift.

In the VCM Plant, most of the maintenance and operation personel infrequently receive a noise dose in excess of 0.5. Therefore, a formal hearing conservation program should be maintained for these employees. For compliance with the proposed regulation, it would not be necessary to include office and warehouse personnel in the hearing conservation program.

OTHER PROJECTS

Calibration of Dosimeter Monitoring System

The new OSHA Standard for exposure to vinyl chloride is explicit in its delineation of the requirement for accuracy in the personnel monitoring technique (see p. 17). However, there was considerable misunderstanding in interpreting the statement. The question arose concerning whether the accuracy requirements refer to the quantitative chemistry technique, to the sampling strategy, to the sampling mechanism, or to all three; i.e., the total monitoring system. There also was apparently some question as to the meaning of the "95 percent confidence level." To elucidate the concept of statistical confidence levels for the VCM Plant staff, the following presentation was developed.

Confidence Level

The 95 percent confidence level requirement essentially recognizes the fact that no measuring system is perfectly accurate and is an attempt to quantify how inaccurate the technique may be. It is a statistical concept that is perhaps best explained using an example.

Assume that the known concentration of vinyl chloride vapor in a particular area is exactly 5 parts per million (ppm). Assume further that a large number of sample measurements, say 800, are taken. Obviously, due to the inherent inaccuracy of any measuring system, the values obtained from the 800 observations will not all equal exactly 5 ppm. Hopefully, the vast majority of the results will be very close to 5 ppm but we would expect a few to fall farther away. Suppose that the 800 sample observations could be summarized as shown in Table 1.

TABLE 1

CLASS INTERVAL (ppm)	FREQUENCY
0.5	0
0.5-1.5	13
1.5-2.5	52
2.5-3.5	97
3.5-4.5	156
4.5-5.5	175
5.5-6.5	144
6.5-7.5	102
7.5-8.5	48
8.5-9.5	12
9.5-10.5	1
10.5	0

In Table 1 the "Frequency" column represents the number of sample measurements which fell within the corresponding Class Interval Range. These data can be displayed graphically by constructing a histogram (see Figure 9). If the number of observations is increased infinitely and the sign or range of the class interval is decreased to an infinitely small size, the resulting graph would be a continuous curve approximating the well-known normal distribution or "bell curve" as shown in Figure 10.

Any normal distribution is completely specified if two parameters are known. First is the mean, or arithmetic average, which is defined as the sum of the values of the observations divided by the number of observations. The second necessary parameter is the standard deviation which can be calculated using the following formula:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}} \tag{10}$$

where σ = standard deviation

x_i = value of individual observation

$\bar{x}$ = mean

n = number of observations

If only a representative sample of observations is to be made, an estimate of the population standard deviation can be made using the following formula:

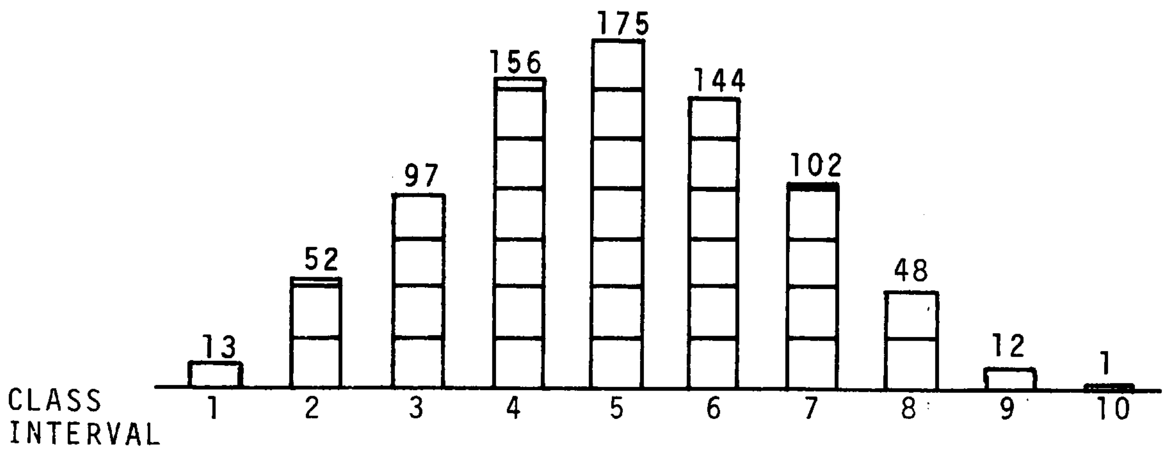


Figure 9. Histogram.

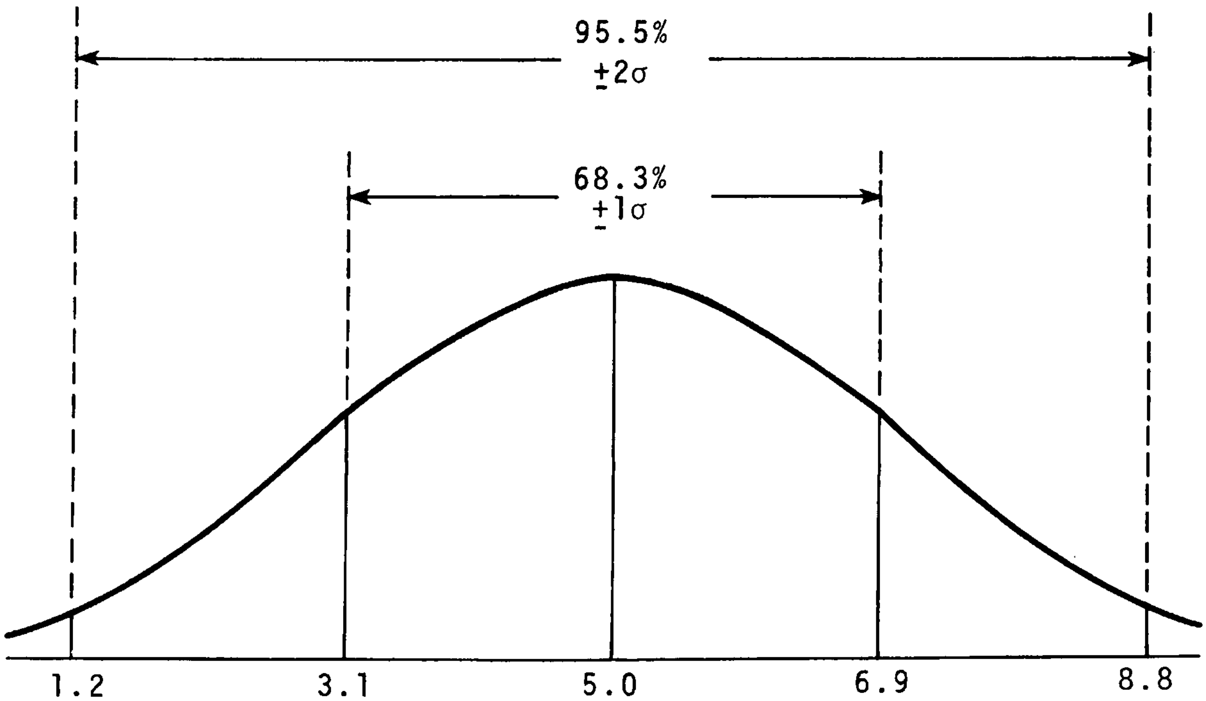


Figure 10. Normal curve.

$$S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n - 1}} \tag{11}$$

Assume that in order to estimate the concentration of VCM in the area with a known concentration of 5 ppm, ten sample measurements are taken with results shown below.

CONCENTRATION (ppm)	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
$x_1 = 5.1$	0.1	0.01
$x_2 = 4.8$	-0.2	0.04
$x_3 = 3.2$	-1.8	3.24
$x_4 = 2.5$	-2.5	6.25
$x_5 = 3.8$	-1.2	-.44
$x_6 = 3.2$	-1.8	3.24
$x_7 = 7.1$	2.1	4.41
$x_8 = 5.6$	0.6	0.36
$x_9 = 8.5$	3.5	12.25
$x_{10} = 6.2$	1.2	1.44
	50.0	32.68

The sample estimates of the mean and standard deviation are then calculated as follows:

$$\bar{x} = \frac{x_i}{n} = \frac{50}{10} = 5.0$$

$$S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n - 1}} = \sqrt{\frac{32.68}{9}} = 1.91$$

Because about 95 percent of a large number of observations will be expected to fall within plus or minus 2 standard deviations of the mean, we would expect 95 percent of all future measurements to fall within plus or minus 3.8 of 5.0. In other words, the measurement technique shows the concentration to be 5.0 ppm $\pm$ 3.8 ppm with a 95 percent confidence level.

Interpretation of Standard

Correspondence with the Area and Regional Offices of the Occupational Safety and Health Administration yielded information concerning official interpretation of the accuracy requirements. In their view, the implied error is cumulative error incurred in making measurements of TWA exposures. The sampling strategy, sampling mechanism, and quantitative analysis procedure all contribute to the cumulative error. Sampling strategy (i.e., grab samples versus integrated samples) has the greatest potential influence on the accuracy. However, a sampling strategy which calls for sampling continuously with a personal sampler throughout the duration of exposure in the time period involved (15 minutes or 8 hours) will, according to OSHA's interpretation, introduce essentially no error. The remaining potential error sources, sampling mechanism and quantitative analysis, were measured by proper calibration techniques.

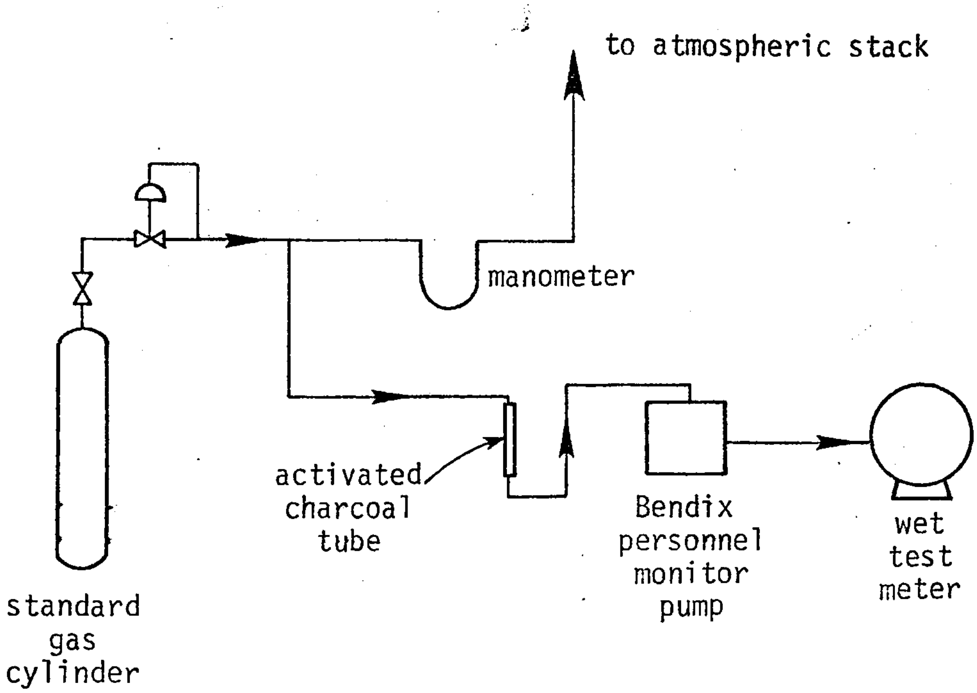
Calibration Techniques

Proper calibration of personal sampling system involved the use of purchased standard gas cylinders containing known concentrations of vinyl chloride. Calibration was conducted at three concentration levels: 2.0 ppm, 0.8 ppm, and 0.25 ppm. A schematic of the calibration setup is shown in Figure 11.

Replicate samples, analyzed using normal techniques of gas chromatography permitted the calculation of means, standard deviations, and 95 percent confidence levels shown in Table 2. These data confirmed that the sampling mechanism and quantitative analysis technique used by VCM Plant personnel exceed OSHA accuracy requirements.

TABLE 2

KNOWN CONCENTRATION	$\bar{x}$	LCL	UCL	OSHA REQUIREMENTS
2.0 ppm	2.1	1.9	2.3	1.5 to 2.5 ($\pm$25%)
0.8 ppm	0.9	0.8	1.1	0.5 to 1.1 ($\pm$35%)
0.25 ppm	0.24	0.15	0.33	0.12 to 0.38 ($\pm$50%)



NOTES:

1. Standard gas cylinders of 2 ppm, 0.8 ppm, and 0.25 ppm were used.

2. Flowrate from standard gas cylinder was set by observing overflow through manometer

Figure 11. VCM personal monitoring system--calibration schematic.

Turnaround Loss Control Program

My primary project for the month of April was assisting with the loss control activities associated with the occupational health and safety aspects of the annual VCM Plant turnaround, which began April 5 and continued for approximately three weeks. Approximately 90 casual (temporary) employees were hired to assist in cleaning vessels and columns, replacing reactor catalyst and so forth. Historically, a large percentage of the losses associated with personnel injuries each year occur during the turnaround. To reverse that trend, special emphasis was placed on the prevention of losses by controlling the health and safety aspects of turnaround work. As a result, injuries requiring first aid only treatment were reduced 52 percent from the previous turnaround, injuries requiring only medical treatment were reduced by 80 percent and losses resulting from disabling injuries were eliminated entirely.

My time involved with the turnaround safety program can be categorized into three basic areas: (1) personal orientation and familiarization with both federal and company safety regulations and procedures, (2) personnel training and instruction, and (3) direct safety supervision.

The new OSHA "Standard for Exposure to Vinyl Chloride" requires that all employees be instructed in the nature of the health hazard from chronic exposure to vinyl chloride including the specific nature of the operations having potential for exposure to VCM in excess of the permissible limit; the purpose for, and proper use of, respiratory protective equipment; the VCM monitoring program, medical surveillance program; etc. No VCM exposure was anticipated for the casual employees because the plant was non-operational for the duration of the turnaround. All equipment including lines, vessels, columns and reactors was cleared of VCM. Nevertheless, to insure compliance with federal regulations, each casual employee was afforded training in the health aspects of exposure to vinyl chloride. I assisted in this instruction.

It was obvious that much preparatory work had gone into the design and implementation of the turnaround loss control program. Engineering design controls significantly reduced exposure to toxic catalyst dust reducing both the inhalation and eye irritation hazards. Formal procedures and guidelines had been established, printed, and distributed to leadmen and supervisors. Appropriate personal protective equipment was ordered in advance, maintained in stock and issued when required for hazardous operations.

Direct loss control supervision involved evaluation of operational procedures and techniques plus observation of turnaround performance. Tasks of this type, because of their involvement with people, are, I believe, among the most difficult and rewarding of engineering jobs. It is difficult to know too much about the reactions of people and their responses to certain situations. Convincing employees that prescribed work procedures are personally important to them is a formidable task. Each worker is an individual who must be independently approached and dealt with uniquely.

The National Safety Council [7] lists support from management among the first prerequisites to a viable loss control program. The validity of this axiom was substantiated by the improvement in the control of personal injuries and their associated losses during this turnaround. The plant manager attended most of the briefings before and during the turnaround and often commented upon the value of following prescribed work practices. His interest and insistance upon adherence to prescribed rules were, I believe, instrumental in instilling the proper attitude in plant supervisors and employees at all echelons. Gratifying employee cooperation and a reduced injury and loss frequency and severity were the results.

During the actual turnaround construction, my time was spent monitoring employee performance to assure compliance with prescribed procedures and personal protective equipment requirements. In addition, I was consulted by leadmen and supervisors where questions arose as to the adequacy of scaffolding construction, rigging techniques, safeguards for sandblasting and asbestos operations, and so forth. The levels of silica, asbestos, noise, VCM, and EDC in work areas were also monitored.

SUMMARY AND OBSERVATIONS

There is today an increasing emphasis on the preservation of our environment and the conservation of non-renewable resources. A significant portion of this thrust is directed toward the occupational environment. Recognition of the myriad of hazardous materials and conditions to which industrial workers are exposed has gained the attention of management, labor and government.

The Occupational Safety and Health Act of 1970 was promulgated to provide, insofar as possible, "a workplace free from recognized hazards."

Industry has been challenged to maintain its level of productivity while preserving natural resources, both environmental and human. To meet this challenge new techniques must be developed for the recognition, evaluation and control of the occupational environment. In many cases classical industrial hygiene engineering methodologies are inadequate to comply with the rigid governmental requirements written into current legislation.

It is felt that the Doctor of Engineering from Texas A&M University, armed with both the technical training and the awareness of non-technical problems is well equipped to wrestle with such problems.

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APPENDIX A

REGRESSION ANALYSIS CALCULATIONS

REGRESSION CALCULATIONS

Nomenclature

x_i = ith observation of simulated automated system results

y_i = ith observation of dosimeter results

b = calculated estimate of slope of regression line

a = intercept of regression line

n = number of paired data samples

$S_{y/x}$ = variation of y with respect to x

UCL = upper confidence limit (line)

LCL = lower confidence limit (line)

$D = (y_i - x_i)$

Reduced Data

$$n = 40$$

$$\sum_{i=1}^{n} x_i = 12.78$$

$$\bar{x} = 0.3195$$

$$\sum_{i=1}^{n} (x_i - \bar{x})^2 = 7.5943$$

$$\sum_{i=1}^{n} y_i = 8.49$$

$$\bar{y} = 0.2123$$

$$\sum_{i=1}^{n} (y_i - \bar{y})^2 = 2.4352$$

$$\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y}) = 2.7072$$

$$\sum_{i=1}^{n} (D_i - \bar{D})^2 = 4.6413$$

Determination of a and b

$$b = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n} (x_i - \bar{x})^2} = \frac{2.7072}{7.5943} = 0.3565$$

$$a = \bar{y} - b\bar{x} = 0.2123 - (0.3565)(0.3195) = 0.0984$$

Determination of 95 Percent Confidence Limits for b

$$S_{y/x} = \frac{\sum_{i=1}^{n}(y_i - \bar{y})^2 - b\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{n - 2}$$

$$= \frac{2.4352 - (0.3565)(2.7072)}{38}$$

$$= 0.0387$$

$$UCL_b = b + t_{.025;38}\frac{X_{y/x}}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}} = 0.3565$$

$$+ \frac{(2.022)(0.0387)}{7.5943}$$

$$= 0.3565 + 0.0284$$

$$= 0.3849$$

$$LCL_b = 0.3565 - 0.0284 = 0.3281$$

Determination of 95 Percent Confidence Limits for a

$$UCL_a = a + t_{.025;38}\, S_{y/x}\sqrt{\frac{1}{n} + \frac{\bar{x}^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2}}$$

$$= 0.0984 + (2.022)(0.0387)\sqrt{\frac{1}{40} + \frac{(0.3195)^2}{7.5943}}$$

$$= 0.0984 + 0.0153 = 0.1137$$

$$LCL_a = 0.0984 - 0.0153 = 0.0831$$

"t" Test to Test Hypothesis that a is not Significantly Different from Zero

$$t = \left| \frac{a - A_o}{S_{y/x}\sqrt{\frac{1}{n} + \frac{\bar{x}^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2}}} \right| = \frac{0.0984 - 0}{(0.0387)\sqrt{\frac{1}{40} + \frac{(0.3195)^2}{7.5943}}}$$

$$= 12.96829 > t_{\alpha/2;n-2} = 2.022$$

Therefore $a \neq 0$, $a = 0.0984$

Regression Line

$$y = a + bx = 0.0984 + (0.3565)x$$

Determination of Confidence Interval at Various Points

$x' \equiv$ observed value

$y' \equiv$ predicted value

$$y' = a + bx' \pm t_{\alpha/2;n-2}\, S_{y/x}\sqrt{\frac{1}{n} + \frac{(x' - \bar{x})^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2}}$$

Sample Calculation: $x' = 1.00$ ppm

$$y' = 0.0984 + (0.3565)(1.00) \pm (2.022)(0.0387)$$

$$\cdot \sqrt{\frac{1}{40} + \frac{(1.00 - 0.3195)^2}{7.5943}}$$

$$y' = 0.4549 \pm 0.0229$$

x'	y'	UCL_y	LCL_y
0.5	0.2767	0.2901	0.2633
1.0	0.4549	0.4778	0.4320
1.5	0.6332	0.6689	0.5975
2.0	0.8114	0.8607	0.7621
2.35	0.9362	0.9951	0.8773
2.5	0.9897	1.0528	0.9266

APPENDIX B

CALIBRATION OF VCM DOSIMETER MONITORING SYSTEM

2.0 ppm Vinyl Chloride Standard Gas

x_i	x_i^2
2.03	4.12
1.77	3.13
2.21	4.88
2.23	4.97
2.14	4.58
2.23	4.97

$$\sum x_i = 12.61 \qquad \bar{x} = \frac{x_i}{n} = \frac{12.61}{6} = 2.10$$

$$\sum x_i^2 = 26.65$$

(NOTE: x_i = result of ith sampling repetition)

$$S = \sqrt{\frac{\sum x_i^2 - \frac{\sum (x_i)^2}{n}}{n - 1}} = \sqrt{\frac{26.65 - \frac{(12.61)^2}{6}}{5}}$$

$$= 0.17$$

t = 2.57 (from table of Student's "t" distribution)

Upper Confidence Limit

$$U = \bar{x} + t \frac{S}{\sqrt{n}} = 2.10 + 2.57 \left(\frac{0.17}{\sqrt{6}}\right) = 2.3 \text{ ppm}$$

Lower Confidence Limit

$$L = \bar{x} - t \frac{S}{\sqrt{n}} = 2.10 - 2.57 \left(\frac{0.17}{\sqrt{6}}\right) = 1.9 \text{ ppm}$$

OSHA Accuracy Requirement

2.0 ppm ± 25% = 2.0 ± 0.5 ⟶ 1.5 ppm to 2.5 ppm

0.8 ppm Vinyl Chloride Standard Gas

x_i	x_i^2
0.78	0.61
1.05	1.10
1.05	1.10
1.01	1.02
0.98	0.96
0.74	0.55
0.94	0.88

$$\sum x_i = 6.55 \qquad \bar{x} = \frac{\sum x_i}{n} = \frac{6.55}{7} = 0.94$$

$$\sum x_i^2 = 6.23$$

(NOTE: x_i = result of ith sampling repetition)

$$S = \sqrt{\frac{\sum x_i^2 - \frac{(\sum x_i)^2}{n}}{n - 1}} = \sqrt{\frac{6.23 - \frac{(6.55)^2}{7}}{6}}$$

$$= 0.13$$

t = 2.447 (from table of Student's "t" distribution)

Upper Confidence Limit

$$U = \bar{x} + t\frac{S}{\sqrt{n}} = 0.94 + 2.447\left(\frac{0.13}{\sqrt{7}}\right) = 1.06$$

Lower Confidence Limit

$$L = 0.94 - 0.12 = 0.82$$

OSHA Accuracy Requirement

0.8 ppm $\pm$ 35% = 0.8 $\pm$ 0.28 $\longrightarrow$ 0.52 ppm to 1.08 ppm

0.25 ppm Vinyl Chloride Standard Gas

x_i	x_i^2
0.29	0.08
0.11	0.01
0.26	0.07
0.26	0.07
0.26	0.07
1.18	0.30

$$\sum x_i = 1.18 \qquad \bar{x} = \frac{\sum x_i}{n} = \frac{1.18}{5} = 0.24$$

$$\sum x_i^2 = 0.30$$

(NOTE: x_i = result of ith sampling repetition)

$$S = \sqrt{\frac{\sum x_i^2 - \frac{(\sum x_i)^2}{n}}{n-1}} = \sqrt{\frac{0.30 - \frac{(1.18)^2}{5}}{4}}$$

$$= 0.07$$

t = 2.776 (from table of Student's "t" distribution)

Upper Confidence Limit

$$U = \bar{x} + t\frac{S}{\sqrt{n}} = 0.24 + 2.776\left(\frac{0.07}{\sqrt{5}}\right) = 0.33 \text{ ppm}$$

Lower Confidence Limit

$$L = \bar{x} - t\frac{S}{\sqrt{n}} = 0.24 - 0.09 = 0.15 \text{ ppm}$$

OSHA Accuracy Requirement

0.25 ppm $\pm$ 50% = 0.25 $\pm$ 0.13 ppm $\longrightarrow$ 0.12 to 0.38 ppm

APPENDIX C

CHRONOLOGY OF SIGNIFICANT EVENTS DURING INTERNSHIP

January 6, 1975, through August 22, 1975

Date	Event
January 6	Arrival in Lake Charles. Assignment to VCM Plant.
January 10-30	Duty as board operator in ethylene plant control room.
February 4	Formulation of Conoco supervisory committee and on-site internship objective.
February 19	Oral presentation to plant management on interpretation of statistical confidence limits requirements in OSHA VCM Standard (see page 40).
March 5-15	Data gathering for first phase of plant noise survey (low production rates, lbs/day).
April 4	Periodic review of progress toward internship objectives with supervisory committee.
April 5-25	Loss control supervisory duties during VCM Plant "turnaround" (major plant maintenance and overhaul).
April 16	Submission of written proposal for VCM monitoring study to supervisory committee.
May 2-16	Data gathering for first phase of plant noise survey (full production rates, lbs/day).
May 5-20	Calibration of VCM dosimeter monitoring system to ensure compliance with OSHA accuracy requirements (see page 46).

May 14	Periodic review of progress toward internship objectives with supervisory committee.
May 29	Submission of report on results of first phase of VCM Plant noise exposure study to internship supervisory committee and TAMU committee chairman.
June 1-30	Data gathering for personnel location (Time Chart--Figure 4, page 20).
June 24	Trip to Georgia-Pacific Plant in Plaquemine, La., to view automated VCM monitoring system in operation.
July 7	Periodic review of progress toward internship objectives with supervisory committee.
July 14-21	Surveys of occupational exposures to hazardous chemicals in chemical plant complex.
July 29	Submission of report on personnel exposures to elemental chlorine in the VCM Plant to supervisory committee and TAMU committee chairman.
August 5	Submission of report on results of second phase of VCM Plant noise exposure study to supervisory committee and TAMU committee chairman.
August 12	Oral presentation on hazards of VCM exposure for representative from the Bureau of Explosives, Association of American Railroads.

August 21	Submission of final report on results of VCM Plant noise survey to supervisory committee and TAMU committee chairman.
August 22	Oral review of internship for representatives from Conoco and TAMU.